Direct Mass Measurements from Uranium Projectile and Fission Fragments in Ground and Isomeric State *

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With the FRS Ion Catcher [1] several projectile and fission fragments were produced in an online experiment in October 2014, separated in-flight, range-bunched, slowed down at the FRS and thermalized in a cryogenic stopping cell (CSC) [2, 3]. A Multiple-Reflection Time-Of-Flight Mass Spectrometer (MR-TOF-MS) [4] served as mass tagger behind the FRS and performed high accuracy mass measurements of several short-lived exotic nuclei produced with low yields.

In the preparation of the online experiment the performance of the MR-TOF-MS was improved. The kinetic energy of the ions in the time-of-flight section of the MR-TOF-MS has been increased to 1300 eV. Mass resolving powers (FWHM) for ^{133}Cs of 120,000, 220,000 and 420,000 of 2.3 ms, 4.6 ms and 18.3 ms total time-of-flight have been obtained, respectively. A novel RF quadrupole-based switchyard was installed and commissioned in the beam line. It provides the opportunity to additionally inject calibrant ions into the RF beam line by merging beams from up to 5 beam lines.

Several projectile fragments produced by bombarding 1000 MeV/u ^{238}U on a ^{9}Be target were measured for the first time directly by MR-TOF-MS with different charge states. Among these ^{213}Rn^{1+} and ^{220}Ra^{2+} with a half-life of only 19.5 ms and 17.9 ms, respectively.

In the region of the chart of the nuclides of the doubly-magic nucleus ^{132}Sn several nuclei have long-lived nuclear isomers. Various fission fragments of Uranium and their long-lived isomers were measured with the MR-TOF-MS with up to 430 turns, corresponding to a time-of-flight of 15.3 ms. The ground state and $19/2^-$ isomer of ^{133}I were separated and measured simultaneously at a mass resolving power of 370,000 with the MR-TOF-MS (see figure 1). This allows the determination of the mass of both states directly and therefore the excitation energy of the isomeric state. Furthermore, the abundance ratio between the ground state and the isomer was measured. This will lead to a better understanding of the production mechanism of exotic nuclei at accelerator facilities.

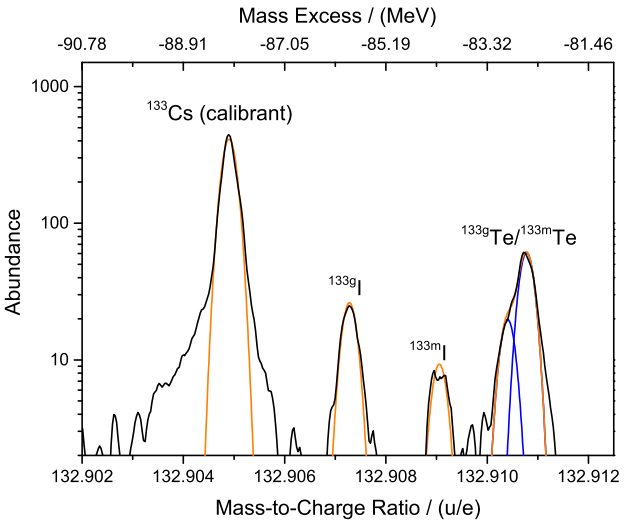

Figure 1: Fission fragment mass spectrum (430 turns) produced by 1000 MeV/u ^{238}U on a ^{9}Be target after a time-of-flight of 15.3 ms in the analyzer of the MR-TOF-MS.

High accuracy mass measurements of the ground state and $25/2^+$ isomer of ^{211}Po were performed. In addition, the MR-TOF-MS, equipped with a Bradbury-Nielsen gate (BNG), was used as isomer separator to deliver a pure isomeric beam to a silicon detector was placed. Alpha spectroscopy of the isomer was performed. This work opens up new perspectives for decay experiments with isomers.

References

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